SECTION 6.0 – DD 963 CLASS

TABLE OF CONTENTS

LIST OF TABLES

6.0   DD 963 CLASS

The USS SPRUANCE Class (DD 963) was selected to represent the group of vessels that rely on gas turbines for main propulsion and have a wet bilge design. The USS SPRUCE (DD 963) was selected as the representative vessel class because this vessel class is comprised of the largest number of vessels (approximately 23 percent) vessels in the group and is evenly distributed between the Pacific and Atlantic fleets. Additionally, the DD 963 Class is close to the group average length and displacement. No new vessels with gas turbine and wet bilge are in the design or construction phase. Although these vessels are similar to the DDG 51 Class, their designs differ in the way that bilgewater is collected. This chapter presents the physical parameters, chemical data, field data, descriptive information, and generation rates for the DD 963 Class vessels.

For Vessels with gas Turbines and wet bilge, waste is pumped to the oily waste holding tank (OWHT). Oil removed from the wastestream by the oil water separator (OWS) is directed to the waste oil tank (WOT) and held for pierside disposal. Sampling was conducted in-port and underway aboard one of the ships in this group, USS DAVID R. RAY (DD 971), on January 10-18 and February 7-11, 2000.

The primary bilge OWS system currently installed onboard DD 963 Class vessels includes one parallel plate 10 gpm gravity coalescence type oil-water separator. These vessels typically process bilgewater both pierside and underway, discharging the processed effluent into the surrounding waters. The processing needs of the ship within 12 nm are met through the use of one 10 gpm system; therefore subsequent characterization analyses are based on a 10 gpm system processing the entire volume of untreated bilgewater.

The following summarizes the general vessel characteristics for the DD 963 Class vessels.

General Vessel Characteristics (Navy, 2001a)

Draft (ft):	32
Length at waterline (ft):	529
Beam at waterline (ft):	55
Displacement (tons):	9036

6.1   BASELINE DISCHARGE

The baseline discharge is defined as the direct discharge of the bilgewater, collected in the OWHT. This discharge is assumed to occur, at the normal OWS flow rate while bypassing the OWS. It is important to note that although the term baseline discharge is used for this report, the Armed Forces do not discharge bilgewater from the OWHT directly overboard without treatment. This scenario is included in the UNDS analysis simply to establish a reference point for subsequent comparisons. The baseline analysis will be based on discharging the entire volume of untreated bilgewater at 10-gpm through a single OWS system discharge port.

6.1.1   Characterization Data

Sources of bilgewater aboard the DD 963 Class vessels include: condensate, which forms on the interior hull and piping; evaporator distillate dump; machinery steam and condensate drains; leaking propeller shafts, pump and packing glands; and leaking piping, valves, and flanges. The liquid phase of this fluid may contain oily constituents including DFM (emergency diesel generators), JP-5 fuel (main gas turbine engines and aircraft), 2190TEP lube oil (auxiliary equipment), 9250 lube oil (emergency diesel generators), synthetic lube oil (main engines and aircraft engines), hydraulic oil (elevators, cranes, and winches), and various grades of grease lubricants used on pulleys, cables, valves, and other components which may have dripped directly into the bilge spaces, or other ship spaces communicating with the bilge. Other potential bilge constituents include dissolved metals and metal-containing particulate matter

6.1.1.1 *Physical Parameters*

The physical parameters presented in this section include values necessary for hydrodynamic modeling of the discharge, which differs from shipboard data. The characteristics of the DD 963 baseline discharge (Table 6-1) were developed using assumption that bilgewater is discharged overboard at the OWS design flow rate(s) while bypassing the OWS.

Table 6-1. Discharge Characteristics for DD 963 Baseline

Modeling Parameters	Values
Vertical (feet)	+20
Transverse (feet)	-27.5
Length (feet)	218
Diameter (inches)	1.5
Temperature (°C)	25
Salinity (ppt)	15.7
Flow (gpm)	10
Velocity (ft/sec)	1.8
Duration of Release Event (hr)	4.5
Time Between Release Events (hr)	21.6

Vertical – Approximate distance from waterline to discharge port (+, above, -, below)
Transverse – Distance from centerline to discharge port (+, port, -, starboard)
Length – Approximate distance from forward perpendicular to discharge port
Diameter – Diameter of discharge port
ppt – parts per thousand
gpm – gallons per minute
ft/sec – feet per second
hr – hour

The influent of the OWS is characterized in this report as the baseline from which a relative analysis of the marine pollution control device (MPCD) options can be performed. The parameters for the engineering and modeling recommendation summary are based on the specifications in DD 963 installation drawings of the OWS and a ship check.

Several parameters were identified for the discharge port on the DD 963. These parameters include: discharge port location in relation to the waterline (vertical), distance from the centerline to discharge port (transverse), approximate distance from forward perpendicular to discharge port (length), and discharge port diameter (diameter) (Meade, 2001a). Additional discharge characteristics identified for modeling purposes include temperature, salinity, flow rate, discharge velocity, duration of release event, and time between release events.

The temperature of bilgewater is dependent on several factors. Bilgewater on a DD 963 Class vessel is temporarily held in the ship's bilge or in an OWHT. Consequently, ambient air temperature inside the machinery space and the temperature of the source bilgewater can have an effect on bilgewater temperature. However, because the bilge and OWHT are separated from the waterbody only by the ship's hull, bilgewater is often at or near the ambient water temperature. Because bilgewater is not used as a cooling or heating fluid and there is ample opportunity for thermal equilibration (heat transfer through the metal hull), bilgewater is assumed to be at the temperature of the receiving water. Further, for modeling purposes, the ambient water temperature is assumed to be 25º C.

Unlike other physical parameters used for modeling purposes, sampling data from the OWS influent were used to determine the salinity value for DD 963 baseline discharge (Navy, 2000). To facilitate obtaining a representative salinity value, an average of the sample results was used to determine one representative salinity value for the baseline discharge (the same value is used for subsequent analysis of the primary treatment MPCD; see Section 6.2.1.1).

Of the remaining discharge characteristics required for modeling, flow, velocity, and duration of release event are interdependent. The exit velocity out of the discharge port is equal to flow rate divided by the cross-sectional area of the discharge pipe (velocity = flow/area). The flow rate for the baseline is the rated capacity of the MPCD (i.e., 50 gpm for the gravity coalescer). The area is calculated from the diameter of the discharge pipe. The duration of the release event is based on the size of the OWHT, the rated capacity of any control in place, and the bilgewater generation rate. The volume of bilgewater processed is based upon Navy practices, which assumes processing begins when the OWHT reaches 90 percent capacity (Smith, B., 2001). The duration is calculated as follows:

Duration of Release = (0.90 * OWHT Volume) / (Rated MPCD Capacity – Bilgewater Generation Rate)

The time between release events is determined using bilgewater generation rate data and OWHT capacities. Again, for purposes of modeling, it is assumed that the entire discharge release/non-release cycle (a release event followed by the time between release events) occurs while the vessel is pierside. The formulas used to determine some of the values in the physical parameters section are presented in Appendix A.

6.1.1.2 *Constituent Data, Classical Data, and Other Descriptors*

Chemical Data

During Phase II, sampling was conducted aboard one vessel of the DD 963 Class, the USS DAVID R. RAY (DD 971), on January 10-18 and February 7-11, 2000. These sampling episodes serve as the primary source of chemical data for this vessel group. Three bilgewater/ OWS discharge samples were collected during the first underway period and a fourth sample was collected during the second underway period.

The samples were analyzed by Ecology and Environment, Inc., Pacific Analytical, Inc., and Q Biochem (formally ETS Analytical Services, Inc.). The results were reviewed by EPA and DoD to determine the quality of the analytical data; however some sample data were excluded in the final calculations, as documented in the *Draft Sampling Episode Report -USS DAVID R. RAY* (Navy, 2000d), based upon SCC review. Data quality was considered for all analyses conducted. To ensure data quality after reviewing documented matrix spike failures, and process information discrepancies, a confirmation analysis was conducted for pesticides. The confirmation analysis revealed that there were no pesticides present in the reanalyzed samples. As a result, pesticides are not included in bilgewater discharge profiles (Navy and EPA, 2002).

SCC validated data include the constituents present in the waste stream and their concentrations. Sampling was conducted on the OWS influent, which was considered the untreated baseline for this vessel group. Several methods used for analyses during Phase I are different than those used for Phase II analyses. For example, mercury was analyzed by EPA Method 1631 for Phase I, but for Phase II samples, EPA Method 1620 was used. The primary difference between these methods is that Method 1631 has a much lower detection limit than Method 1620. The decision to use Method 1620 in place of Method 1631 was due to the susceptibility of Method 1631 to a variety of matrix interferences stemming from liquids released from machinery room equipment. After reviewing Phase I analytical data, EPA Method 1620, with the higher detection level, was found to be sufficient for Phase II because constituents were found in sufficiently high concentrations that the cost of using more sensitive and expensive techniques was unjustified. The sampling and analytical decisions made for samples collected on DD 971 are detailed in the Sampling and Analysis Plan (SAP). Four field samples were taken during each sampling episode from the influent (representing the baseline) to the OWS. For more information, see the *Sampling Episode Report –USS DAVID R. RAY (DD 971)* (Navy, 2000d).

Constituent concentrations are represented as the geometric mean of the measured concentrations in the influent samples. See Appendix E for final constituent values.

Field Information

Field data refers to information obtained at the time of sample collection. The field tests conducted on DD 971 included pH, temperature, salinity, specific conductance, and free and total chlorine. For these field tests, the reported value was determined by calculating an average of all field measurements. Table 6-2 lists the values for each parameter.

Table 6-2. Field Testing Parameters for DD 963 Baseline

Field Parameter	Values
pH	7
Temperature	16 °C
Salinity	16 ppt
Specific Conductance	26,000 µS/cm
Free Chlorine	0.34 mg/L
Total Chlorine	0.44 mg/L

Descriptive Information

Descriptive information refers to data collected to facilitate the environmental effects analysis and is presented here to give a more complete description of the discharge. This information included observations or measurements of color, floating materials, odor, settleable materials, and turbidity/colloidal matter. For the parameters where the results were based on field tests, an average was used as the parameter value except in cases where total dissolved gases was measured. For this parameter, the lowest dissolved oxygen (DO) value was reported in the profile report and used in the environmental effects analysis, because lower DO values are a greater environmental concern. Measurement of foam, and scum were not taken for the DD 963 Vessel class. Table 6-3 lists values for the descriptive data.

Table 6-3. Descriptive Discharge Profile for DD 963 Baseline

Narrative Parameter	Field Observations
Color	Dark gray
Floating Materials	None specifically observed in samples collected
Foam	None specifically observed in samples collected
Odor	Fuel smell
Scum	None specifically observed in samples collected
Settleable Materials	None specifically observed in samples collected
Total Dissolved Gases	Not measured in samples collected
Turbidity/Colloidal Matter	Cloudy

6.1.1.3 Discharge Generation Rates For Mass Loading

All DD Class vessels are stationed in saltwater ports and do not operate in freshwater. Daily generation rates were obtained from previously reported underway surveys (Navy, 1997a and 1995), which assume that in port generation rates are approximately 25 percent of the underway generation rates. The annual discharge volumes are derived in Table 6-4 by multiplying these reported values by the average number of days that the class spends in port or at sea.

Table 6-4. DD 963 Vessel Group Generation Volumes

Class	Number of Vessels	Days in Port	Days Underway (0-12 nm)	Days Underway (12+ nm)	Daily generation rate per vessel (gal/day)			Annual generation rate per class (gal/year)		
					In port	Underway (0-12 nm)	Underway (12+ nm)	In port	Underway (0-12 nm)	Underway (12+ nm)
AOE 6	4	186	4	175	7.5E+03	3.0E+04	3.0E+04	5.6E+06	4.8E+05	2.1E+07
CG 47	27	166	4	195	2.5E+03	1.0E+04	1.0E+04	1.1E+07	1.1E+06	5.3E+07
DD 963	20	178	4	183	2.5E+03	1.0E+04	1.0E+04	8.9E+06	8.0E+05	3.7E+07
FFG 7	35	168	4	193	6.3E+02	2.5E+03	2.5E+03	3.7E+06	3.5E+05	1.7E+07
T-AKR 310	8	295	20	50	7.5E+03	3.0E+04	3.0E+04	1.8E+07	4.8E+06	1.2E+07
Total	94	-	-	-	2.6E+04	8.3E+04	8.3E+04	8.0E+07	7.5E+06	1.4E+08

6.2 PRIMARY TREATMENT

Gravity coalescer represents the currently installed primary treatment MPCD onboard DD 963 Class vessels. Most ships of the DD 963 Class currently have one 10 gpm system with a single discharge location. Therefore, subsequent analyses are based on a single 10 gpm system processing the entire volume of bilgewater. Primary treatment creates two waste streams: the aqueous fraction, which is discharged overboard, and the oil fraction, which is directed to the onboard waste oil holding tank. The characterization of the aqueous fraction is described below. The oil fraction is subject to collection, holding and transfer (CHT), treated at a properly permitted facility, and applicable Federal, State, and local disposal regulations.

6.2.1 Characterization Data

Characterization data are comprised of physical parameters, chemical data, field data, and descriptive information. Each of these parameters is discussed below. See Section 6.1.1 for identification of possible bilgewater sources.

6.2.1.1 Physical Parameters

The physical parameters used for hydrodynamic modeling purposes, as detailed in Section 6.1.1.1, are not affected by the addition of a primary MPCD. Table 6-5 summarizes the parameters used for modeling purposes.

Table 6-5. Discharge Characteristics for DD 963 Primary Treatment

Modeling Parameters	Value
Option Group	primary treatment
Vertical (ft)	+20
Transverse (ft)	-27.5
Length (ft)	218
Diameter (in)	1.5
Temperature (°C)	25
Salinity (ppt)	15.7
Flow (gpm)	10
Velocity (ft/sec)	1.8
Duration of Release Event (hr)	4.5
Time Between Release Events (hr)	21.6

Vertical – Approximate distance from waterline to discharge port (+, above, -, below)
Transverse – Distance from centerline to discharge port (+, port, -, starboard)
Length – Approximate distance from forward perpendicular to discharge port
Diameter – Diameter of discharge port
ppt – parts per thousand
gpm – gallons per minute
ft/sec – feet per second
hr – hour
°C – Degree Celsius

The formulas used to determine some of the values in the physical parameters section are presented in Appendix A.

6.2.1.2 *Constituent Data, Classical Data, and Other Descriptors*

Chemical Data

During Phase II of Uniform National Discharge Standards (UNDS) development, sampling was conducted while underway on one DD 963 Class vessel, USS DAVID R. RAY (DD 971), and serves as the primary source of chemical data for this vessel group. The samples from this ship were taken prior to and following the gravity coalescer. Based on the samples collected following the gravity coalescer, a final concentration was determined for each constituent. Some analytical data were excluded, as documented in the Sampling Episode Report (SER), based upon SCC review of the data. See Appendix E for final constituent values.

Field Information

Field information refers to data obtained at the time of sample collection. Field tests conducted on the gravity coalescer samples from DD 971 included pH, temperature, salinity, specific conductance (conductivity), and free and total chlorine. For these field tests, the reported value was determined by calculating an average of all field measurements. Table 6-6 lists the values for each parameter.

Table 6-6. Field Testing for DD 963 Primary Treatment

Field Parameter	Values
pH	7
Temperature	16 °C
Salinity	16 ppt
Specific Conductance	26,000 µS/cm
Free Chlorine	0.07 mg/L
Total Chlorine	0.06 mg/L

Descriptive Information

Descriptive observations and tests were conducted on MPCD gravity coalescer samples from the DD 971. This information included observations or measurements of color, floating material, odor, settleable material, and turbidity/colloidal matter. For parameters based on observations (color and odor), the reported determinations were based upon these samples. For the parameters based on measurements, an average was used as the reported value except for the total dissolved gases parameter. For this parameter, the lowest DO value was reported in the profile report and used in the environmental effects analysis, because lower DO values are a greater environmental concern. Floating materials, foam, scum, settleable materials and total dissolved gases were not specifically observed for the samples collected. Table 6-7 lists values for the descriptive data.

Table 6-7. Descriptive Discharge Profile for DD 963 Primary Treatment

Narrative Parameter	Field Observations
Color	Dark gray
Floating Materials	None specifically observed in samples collected
Foam	None specifically observed in samples collected
Odor	Fuel/oil smell
Scum	None specifically observed in samples collected
Settleable Materials	None specifically observed in samples collected
Total Dissolved Gases	Not measured in samples collected
Turbidity/Colloidal Matter	Cloudy

6.2.1.3 *Discharge Generation Rates for Mass Loading*

The use of a primary treatment MPCD does not affect the generation rate of bilgewater; therefore, the baseline generation and annual volume data are used for the annual discharge volume for this MPCD treatment system. It is assumed that the volume change due to the removal of oil by the treatment device is negligible. See Table 6-4, Section 6.1.1.3, for the baseline generation volumes.

6.3 PRIMARY TREATMENT PLUS FILTER MEDIA

This MPCD option involves treatment with a primary treatment MPCD followed by a secondary treatment through filter media. Primary treatment plus filter media creates two waste streams:

the aqueous fraction, which is discharged overboard, and the oil fraction, which is directed to the onboard waste oil holding tank. After initial treatment by the OWS, the aqueous waste stream is either re-directed back to the OWHT for reprocessing or sent to the polisher (i.e., filter media) system. This is controlled by monitoring the waste stream oil concentration with an oil content monitor (OCM). For concentrations greater than 200 ppm, the waste stream is returned to the OWHT for re-circulation through the OWS, whereas for oil concentrations less than 200 ppm, the waste stream is sent on to the filter media system (Navy, 2000c). The filter media discharge is also monitored. Effluent with oil concentration less than 15 ppm, is released overboard while wastewater with a greater than 15 ppm, it is returned to the OWHT for additional processing (Navy, 2000c). The oil fraction is subject to CHT treatment at a properly-permitted facility and applicable Federal, State, and local disposal regulations.

The characterization of the aqueous fraction is described below.

6.3.1   Characterization Data

Characterization data are comprised of physical parameters, chemical data, field data, and descriptive information. These parameters are discussed below. See Section 6.1.1 for a description of possible bilgewater sources.

6.3.1.1   Physical Parameters

The physical parameters used for hydrodynamic modeling purposes, as detailed in Section 6.1.1.1, are not affected by the addition of primary and secondary MPCDs. Table 6-8 summarizes the parameters identified for modeling purposes.

Table 6-8. Discharge Characteristics for DD 963 Primary Treatment plus Filter Media

Modeling Parameters	Values
Option Group	Primary Treatment plus filter media
Vertical (ft)	+20
Transverse (ft)	-27.5
Length (ft)	218
Diameter (in)	1.5
Temperature (°C)	25
Salinity (ppt)	15.7
Flow (gpm)	10
Velocity (ft/sec)	1.8
Duration of Release Event (hr)	4.5
Time Between Release Events (hr)	21.6

Vertical – Approximate distance from waterline to discharge port (+, above, -, below)
Transverse – Distance from centerline to discharge port (+, port, -, starboard)
Length – Approximate distance from forward perpendicular to discharge port
Diameter – Diameter of discharge port
ppt – parts per thousand
gpm – gallons per minute
ft/sec – feet per second
hr – hour
°C – Degree Celsius

The formulas used to determine some of the values in the physical parameters section are presented in Appendix A.

6.3.1.2   Constituent Data, Classical Data, and Other Descriptors

Chemical Data

Using bilgewater effluent data, the Naval Surface Warfare Center Carderock Division (NSWCCD) evaluated the treatment capabilities for filter media. The filter media MPCD is comprised of an oleophilic blend of granular polymer and carbon media. Although the polymer was designed to remove oil by entrainment and sorption, the carbon media will also reduce the concentrations of semi-volatile organic constituents, especially polynuclear aromatic hydrocarbons (PAHs) (Putnam and Singerman, 2001). Table 6-9 contains the treatment capabilities detailed within the NSWCCD report for filter media and the necessary calculations for the primary treatment MPCD constituents.

Table 6-9. Treatment Capabilities of Filter Media (Putnam and Singerman, 2001)

Analyte Class	Empirical Formulas for Constituent Concentrations
Classical	Ammonia as Nitrogen = C_i Nitrite/Nitrate = $0.6C_i$ Oil & Grease (HEM) = $0.3C_i$ TPH (SGT-HEM) = $0.3C_i$ Total Sulfide = $0.2C_i$ TSS = $0.43C_i$
Total Metals	Copper = $0.5M_t$ Iron = $0.4M_t$ Nickel = $0.75M_t$ Zinc = $0.6M_t$ All others = M_t
Semi-Volatile Organics	= $0.4C_i$
Volatile Organics	Chlorobenzene = $0.20C_i$ m+p-Xylene = $0.20C_i$

C_i is the concentration of the constituent in the input stream.
M_t is the total concentration of the metal in the input stream.

Applying these treatment capabilities of filter media to the final results for the constituents of the OWS effluent produces the constituent concentrations expected by incorporating filter media (Table 6-10). See Appendix E for complete list of constituent values.

**Table 6-10. Calculated Constituent Concentrations for DD 963 –
Primary Treatment Plus Filter Media**

Contaminant	CAS Number	Primary Treatment	Data Qualifier	Estimated Concentration Primary Treatment plus Filter Media	Data Qualifier
Classical (mg/L)					
Alkalinity	T005	1.2E+02		1.2E+02	
Ammonia as Nitrogen	7664417	4.2E+00		4.2E+00	
Biochemical Oxygen Demand (BOD)	C003	3.2E+01		3.2E+01	
Chemical Oxygen Demand (COD)	C004	5.5E+02		5.5E+02	
Chloride	16887006	8.9E+03		8.9E+03	
Nitrate/Nitrite	C005	1.1E-01	U	1.1E-01	U
Oil and Grease (as HEM)	C036	1.4E+01		5.0E+00	U
SGT-HEM	C037	6.1E+00		5.0E+00	U
Sulfate	14808798	1.1E+03		1.1E+03	
Total Dissolved Solids	C010	1.5E+04		1.5E+04	
Total Kjeldahl Nitrogen (TKN)	C021	5.5E+00		5.5E+00	
Total Organic Carbon	C012	3.5E+01		3.5E+01	
Total Phosphorous	14265442	9.5E-02		9.5E-02	
Total Sulfide	18496258	1.9E+00		1.0E+00	U
Total Suspended Solids	C009	5.0E+01		2.2E+01	
Volatile Residue	C030	2.4E+03		2.4E+03	

Contaminant	CAS Number	Primary Treatment	Data Qualifier	Estimated Concentration Primary Treatment plus Filter Media	Data Qualifier
Semivolatile Organics (ug/L)					
2,4-Dimethylphenol	105679	2.4E+01		1.0E+01	U
2-Chloronapthalene	91587	1.0E+01	U	1.0E+01	U
2-Methylnapthalene	91576	1.7E+01		1.0E+01	U
Acenapthene	83329	1.0E+01	U	1.0E+01	U
alpha-Terpineol	98555	2.9E+01		1.2E+01	
Bis- (2-ethylhexyl) Phthalate	117817	1.1E+01		1.0E+01	U
Dibenzofuran	132649	1.0E+01	U	1.0E+01	U
Fluorene	86737	1.0E+01	U	1.0E+01	U
Naphthalene	91203	1.3E+01		1.0E+01	U
n-Decane	124185	1.4E+01		1.0E+01	U
n-Docosane	629970	1.2E+01		1.0E+01	U
n-Dodecane	112403	2.0E+01		1.0E+01	U
n-Eicosane	112958	1.6E+01		1.0E+01	U
n-Hexadecane	544763	2.6E+01		1.1E+01	
n-Octadecane	593453	1.5E+01		1.0E+01	U
n-Tetradecane	629594	1.5E+01		1.0E+01	U
p-Cresol	106445	1.4E+01		1.0E+01	U
Phenanthrene	85018	1.0E+01		1.0E+01	U
Volatile Organics (ug/L)					
2-Butanone	78933	5.3E+01		5.3E+01	
2-Propanone	67641	1.5E+02		1.5E+02	
Benzene	71432	3.8E+01		3.8E+01	
Chlorobenzene	108907	1.0E+01	U	1.0E+01	U
Ethylbenzene	100414	2.6E+01		2.6E+01	
m+p-Xylene	179601231	7.4E+01		1.5E+01	
O-Xylene	95476	4.4E+01		4.4E+01	
Toluene	108883	3.5E+01		3.5E+01	
Total Metals (ug/L)					
Aluminum	7429905	8.6E+01		8.6E+01	
Arsenic	7440382	2.8E+00	U	2.8E+00	U
Barium	7440393	3.9E+01		3.9E+01	
Boron	7440428	2.2E+03		2.2E+03	
Cadmium	7440439	1.4E+00		1.4E+00	
Calcium	7440702	1.6E+05		1.6E+05	
Chromium	7440473	3.6E+00		3.6E+00	
Cobalt	7440484	5.1E+00		5.1E+00	
Copper	7440508	4.6E+02		2.3E+02	
Iron	7439896	3.1E+03		1.2E+03	
Lead	7439921	1.7E+00		1.7E+00	

Contaminant	CAS Number	Primary Treatment	Data Qualifier	Estimated Concentration Primary Treatment plus Filter Media	Data Qualifier
Magnesium	7439954	5.3E+05		5.3E+05	
Manganese	7439965	2.2E+02		2.2E+02	
Mercury	7439976	2.0E-01	U	2.0E-01	U
Molybdenum	7439987	7.5E+00		7.5E+00	
Nickel	7440020	2.2E+02		1.7E+02	
Selenium	7782492	2.0E+01	U	2.0E+01	U
Silver	7440224	6.0E+00	U	6.0E+00	U
Sodium	7440235	8.3E+05		8.3E+05	
Thallium	7440280	1.0E+01	U	1.0E+01	U
Tin	7440315	4.8E+00		4.8E+00	
Titanium	7440326	3.2E+00		3.2E+00	
Zinc	7440666	1.8E+03		1.1E+03	

U – Not detected in waste stream

For additional information on the capabilities of filter media, NSWCCD conducted field testing of two filter media systems. The systems were on the USS GONZALES (DDG 66) and the USS ROSS (DDG 71). The testing was undertaken to evaluate the performance of filter media and its ability to improve the quality of the water discharged from the OWS.

Testing showed that although the filter media functioned to remove oil, it was not consistently effective at achieving oil concentrations of less than 15 ppm. In the more favorable of two cases, the oil concentration was less than 15 ppm in only 32 percent of the effluent samples taken. For the second test the filter media system was even less effective at obtaining concentrations below 15 ppm. Both tests demonstrated that the percentage of oil removed by the filter media system was closely related to the OWS influent oil concentration (specifically, the higher the levels of influent particulate, the less efficient the removal process) (Navy, 2001c).

Although the finding did not support filter media achieving the less than 15 ppm oil concentration sought, it was concluded that the filter media system did reduce the discharged oil concentrations below those of the gravity coalescer system alone.

Field Information

Field tests conducted on DD 971 gravity coalescer effluent samples included pH, temperature, salinity, specific conductance, and free and total chlorine. Based on the observed relationship between the gravity coalescer and gravity coalescer plus a secondary MPCD for samples taken for the DDG 51 vessel group, the addition of a secondary MPCD is not expected to change the values for the field parameters. As a result, the average values for the gravity coalescer samples were used to represent the primary treatment plus filter media values for the DD 963 vessel group (Table 6-11).

Table 6-11. Field Testing for DD 963 Primary Treatment plus Filter Media

Field Parameter	Values
pH	7
Temperature	16 °C
Salinity	16 ppt
Specific Conductance	26,000 µS/cm
Free Chlorine	0.07 mg/L
Total Chlorine	0.06 mg/L

Descriptive Information

Descriptive tests were conducted on the MPCD gravity coalescer effluent samples from DD 971. This information included observations or measurements of color, floating material, odor, settleable materials, and turbidity/colloidal matter. The data for these parameters were not specifically observed for the DD 963 vessel group for a gravity coalescer plus filter media MPCD option so the descriptive test could not be captured for this MPCD option. However, based on a review of the filter media results for the DDG 51 vessel group, the change in color from primary treatment to primary treatment plus filter media went from black to dark gray. For the DD 963 Vessel group the primary treatment effluent samples were recorded as dark gray with black solids. Based on a similar degree of change it is assumed that color will be reduced but not eliminated.

A similar degree of change was extrapolated for odor. Floating materials, foam, scum, settleable materials and total dissolved gases were not specifically observed for the samples collected.

6.3.1.3   Discharge Generation Rates for Mass Loading

The use of a primary and secondary MPCD does not affect the generation rate of bilgewater; therefore, the baseline generation and annual volume data are used for the annual discharge volume for this MPCD treatment system. It is assumed that the volume change due to the removal of oil by other treatment devices is negligible. See Table 6-4, Section 6.1.1.3, for the baseline generation volumes.

6.4   PRIMARY TREATMENT PLUS MEMBRANE FILTRATION

This MPCD option involves the waste stream being processed by a primary treatment MPCD followed by the secondary treatment of membrane filtration. Primary treatment plus membrane filtration creates two waste streams: the aqueous fraction, which is discharged overboard, and the oil fraction, which is directed to the onboard waste oil holding tank. The characterization of the aqueous fraction is described below. The oil fraction is subject to CHT, treatment at a properly permitted facility, and applicable Federal, State, and local disposal regulations.

6.4.1 Characterization Data

Characterization data are comprised of physical parameters, chemical data, field data, and descriptive information. Each of these parameters is discussed below. See Section 6.1.1 for identification of possible bilgewater sources.

6.4.1.1 *Physical Parameters*

The physical parameters used for hydrodynamic modeling purposes, as detailed in Section 6.1.1.1, are not affected by the addition of primary and secondary MPCDs. Table 6-12 summarizes the parameters identified for modeling purposes.

Table 6-12. Discharge Characteristics for DD 963 – Primary Treatment plus Membrane Filtration

Modeling Parameters	Values
Option Group	primary treatment plus membrane filtration
Vertical (ft)	+20
Transverse (ft)	-27.5
Length (ft)	218
Diameter (in)	1.5
Temperature (°C)	25
Salinity (ppt)	15.7
Flow (gpm)	10
Velocity (ft/sec)	1.8
Duration of Release Event (hr)	4.5
Time Between Release Events (hr)	21.6

Vertical – Approximate distance from waterline to discharge port (+, above, -, below)
Transverse – Distance from centerline to discharge port (+, port, -, starboard)
Length – Approximate distance from forward perpendicular to discharge port
Diameter – Diameter of discharge port
ppt – parts per thousand
gpm – gallons per minute
ft/sec – feet per second
hr – hour
°C – Degree Celsius

The formulas used to determine some of the values in the physical parameters section are presented in Appendix A.

6.4.1.2 *Constituent Data, Classical Data, and Other Descriptors*

Chemical Data

Using bilgewater effluent data, the NSWCCD evaluated the treatment capabilities for a ceramic ultrafiltration membrane system. Ceramic ultrafiltration membrane (i.e., membrane filtration) systems are hydrophilic with an amorphous silica separation layer atop a highly porous magnesium aluminosilicate substrate (Tompkins and Owsenek, 1996). Within these systems, bilgewater is recirculated through the membrane module at high velocities. The recirculation

effectively increases the time for equilibrium, and the high flow velocities create turbulence and agitation that facilitate equilibration. Recirculation conditions favor the transport of materials between the oil and water phases, particularly from the water to the oil. Processing of inorganic solutes and organic liquids resulted in reduced membrane performance. These constituents were transported through the membrane regardless of whether equilibrium favors the oil phase. Also, in cases where there was a high detergent concentration, there was a temporary but significant decrease in membrane flux.

NSWCCD, in a contractor analysis report by Native American Consultants, Inc., (Putnam and Singerman, 2001) developed the theory that the transport of pesticides, herbicides, volatile organic material, and semivolatile organic material constituents through a ceramic ultrafiltration membrane (i.e., membrane filtration) is related to the water solubility of the constituents, perhaps due to the phase separation achieved by the membrane. Technical data from USS CARNEY (DDG 64) (Rose, Pehrsson, et al., 1997) indicated that most of the constituents that had water solubilities greater than 30 mg/L, passed through the membrane, while most of the constituents that had water solubilities less than 1 mg/L did not pass through the membrane.

Table 6-13 details the membrane filtration treatment capabilities.

Table 6-13. Treatment Capabilities of Membrane Filtration (Putnam and Singerman, 2001)

Analyte Class	Empirical Formulas for Constituent Concentrations
Classical	Ammonia as Nitrogen = C_i Nitrite/Nitrate = C_i Oil & Grease (HEM) = 8.5 mg/L, C_i; whichever is less TPH (SGT-HEM) = 3.5 mg/L, C_i; whichever is less Total Sulfide = $0.15C_i$ TSS = $0.3C_i$
Total Metals	$M_t \leq M_d$, = M_d Otherwise, = $0.2 (M_t - M_d) + M_d$
Semi-Volatile Organics	$S_w \leq 0.1$ mg/L, = 0 $S_w \geq 30$ mg/L, = C_i Otherwise, = $C_i(0.03344 S_w - 0.003344)$
Volatile Organics	$S_w \leq 0.1$ mg/L, = 0 $S_w \geq 30$ mg/L, = C_i Otherwise, = $C_i(0.03344 S_w - 0.003344)$

C_i is the concentration of the constituent in the input stream.
M_t is the total concentration of the metal in the input stream.
M_d is the concentration of the dissolved metal in the input stream.
S_w is the water solubility of the contaminant in mg/L.

Applying these treatment capabilities to the final results for the gravity coalescer discharge produces the expected constituent concentrations for the primary treatment followed by a secondary MPCD option of membrane filtration (Table 6-14). See Appendix E for complete list of constituent values.

**Table 6-14. Calculated Constituent Concentrations for DD 963 –
Primary Treatment Plus Membrane Filtration**

Contaminant	CAS Number	Primary Treatment	Data Qualifier	Estimated Concentration Primary Treatment Plus Membrane Filtration	Data Qualifier
Classical (mg/L)					
Alkalinity	T005	1.2E+02		1.2E+02	
Ammonia as Nitrogen	7664417	4.2E+00		4.2E+00	
Biochemical Oxygen Demand (BOD)	C003	3.2E+01		3.2E+01	
Chemical Oxygen Demand (COD)	C004	5.5E+02		5.5E+02	
Chloride	16887006	8.9E+03		8.9E+03	
Nitrate/Nitrite	C005	1.1E-01	U	1.1E-01	U
Oil and Grease (as HEM)	C036	1.4E+01		8.5E+00	
SGT-HEM	C037	6.1E+00		5.0E+00	U
Sulfate	14808798	1.1E+03		1.1E+03	
Total Dissolved Solids	C010	1.5E+04		1.5E+04	
Total Kjeldahl Nitrogen (TKN)	C021	5.5E+00		5.5E+00	
Total Organic Carbon	C012	3.5E+01		3.5E+01	
Total Phosphorous	14265442	9.5E-02		9.5E-02	
Total Sulfide	18496258	1.9E+00		1.0E+00	U
Total Suspended Solids	C009	5.0E+01		1.5E+01	
Volatile Residue	C030	2.4E+03		2.4E+03	
Semivolatile Organics (ug/L)					
2,4-Dimethylphenol	105679	2.4E+01		2.4E+01	
2-Chloronapthalene	91587	1.0E+01	U	1.0E+01	U
2-Methylnapthalene	91576	1.7E+01		1.4E+01	
Acenapthene	83329	1.0E+01	U	1.0E+01	U
alpha-Terpineol	98555	2.9E+01		1.0E+01	U
Bis-(2-ethylhexyl) Phthalate	117817	1.1E+01		1.0E+01	U
Dibenzofuran	132649	1.0E+01	U	1.0E+01	U
Fluorene	86737	1.0E+01	U	1.0E+01	U
Naphthalene	91203	1.3E+01		1.3E+01	
n-Decane	124185	1.4E+01		1.0E+01	U
n-Docosane	629970	1.2E+01		1.0E+01	U
n-Dodecane	112403	2.0E+01		1.0E+01	U
n-Eicosane	112958	1.6E+01		1.0E+01	U
n-Hexadecane	544763	2.6E+01		1.0E+01	U
n-Octadecane	593453	1.5E+01		1.0E+01	U
n-Tetradecane	629594	1.5E+01		1.0E+01	U
p-Cresol	106445	1.4E+01		1.4E+01	
Phenanthrene	85018	1.0E+01		1.0E+01	U

Contaminant	CAS Number	Primary Treatment	Data Qualifier	Estimated Concentration Primary Treatment Plus Membrane Filtration	Data Qualifier
Volatile Organics (ug/L)					
2-Butanone	78933	5.3E+01		5.3E+01	
2-Propanone	67641	1.5E+02		1.5E+02	
Benzene	71432	3.8E+01		3.8E+01	
Chlorobenzene	108907	1.0E+01	U	1.0E+01	U
Ethylbenzene	100414	2.6E+01		2.6E+01	
m+p-Xylene	179601231	7.4E+01		7.4E+01	
O-Xylene	95476	4.4E+01		4.4E+01	
Toluene	108883	3.5E+01		3.5E+01	
Total Metals (ug/L)					
Aluminum	7429905	8.6E+01		7.5E+01	
Arsenic	7440382	2.8E+00	U	2.8E+00	U
Barium	7440393	3.9E+01		3.5E+01	
Boron	7440428	2.2E+03		2.1E+03	
Cadmium	7440439	1.4E+00		1.0E+00	U
Calcium	7440702	1.6E+05		1.6E+05	
Chromium	7440473	3.6E+00		3.1E+00	
Cobalt	7440484	5.1E+00		4.2E+00	
Copper	7440508	4.6E+02		1.0E+02	
Iron	7439896	3.1E+03		1.4E+03	
Lead	7439921	1.7E+00		1.3E+00	
Magnesium	7439954	5.3E+05		5.2E+05	
Manganese	7439965	2.2E+02		2.2E+02	
Mercury	7439976	2.0E-01	U	2.0E-01	U
Molybdenum	7439987	7.5E+00		7.1E+00	
Nickel	7440020	2.2E+02		1.7E+02	
Selenium	7782492	2.0E+01	U	2.0E+01	U
Silver	7440224	6.0E+00	U	6.0E+00	U
Sodium	7440235	8.3E+05		5.3E+06	
Thallium	7440280	1.0E+01	U	1.0E+01	U
Tin	7440315	4.8E+00		3.0E+00	U
Titanium	7440326	3.2E+00		3.0E+00	U
Zinc	7440666	1.8E+03		4.1E+02	

U – Not detected in waste stream

To further evaluate the treatment capabilities of membrane filtration systems, a study was undertaken by NSWCCD to determine if the chemical constituents found in bilgewater could potentially damage the ceramic membrane systems, thus reducing their ability to process oily waste effectively (Navy, 1996). To facilitate this study, 26 mixtures and compounds with the potential to be found in bilgewater were processed. This testing was intended to determine the

level of fouling following the treatment of these contaminants and their impact on the processing ability of the membrane filtration system.

The evaluation of 11 different types of contaminants and one pH analysis were conducted on a membrane filtration system. The goal of these analyses was to determine the ability of membrane filtration system to consistently produce an effluent that would conform to local and worldwide environmental standards regardless of influent concentrations. Test results indicated that membrane filtration is capable of conforming to these standards while operating over a wide range of pHs and is resistant to chemical attack. High concentrations of inorganic and organic compounds (i.e., saline solutions, paints and primers, oxidizers, aqueous film-forming foam, or treatment preparations) led to reduced membrane performance. However, despite these minor reductions in processing capacity, most membranes recovered significantly when flushed with water for 15 minutes.

Field Information

Field tests conducted on DD 971 included pH, temperature, salinity, specific conductance, and free and total chlorine (Table 6-15). As stated in Section 6.3.1.2, based on the observed relationship between the gravity coalescer and gravity coalescer plus a secondary MPCD for samples taken for the DDG 51 vessel group, the addition of a secondary MPCD is not expected to change the values for the field parameters. As a result, the reported values for the gravity coalescer samples were used to represent the primary treatment plus filter media values for the DD 963 vessel group.

Table 6-15. Field Testing for DD 963 Primary Treatment plus Membrane Filtration

Field Parameter	Values
pH	7
Temperature	16 °C
Salinity	16 ppt
Specific Conductance	26,000 μS/cm
Free Chlorine	0.07 mg/L
Total Chlorine	0.06 mg/L

Descriptive Information

Descriptive tests were conducted on the MPCD gravity coalescer samples from DD 963. This information included observations or measurements of color, floating material, odor, settleable materials, and turbidity/colloidal matter. The data for these parameters were not specifically observed on the DD 963 for a gravity coalescer plus membrane filtration so the descriptive test could not be captured for this MPCD option. However, based on a review of the membrane filtration results for the LSD 41 vessel group, there was no change in color observed from primary treatment to primary treatment plus membrane filtration. Consequently, it is assumed there is no color change from primary treatment to primary treatment plus membrane filtration for the DD 963 vessel group.

A similar degree of change was extrapolated for all narrative parameters for primary treatment plus membrane filtration. A fuel smell was observed in the samples collected and Cloudy is expected for Turbidity/Colloidal Matter parameter. No other parameters were specifically observed for this MPCD option.

6.4.1.3   Discharge Generation Rates for Mass Loading

Because the baseline is based on sending the bilgewater through the OWS system but bypassing the OWS and any secondary treatment device, the baseline generation and annual volume data are used for the annual discharge volume for this MPCD treatment system. It is assumed that the volume change due to removal of oil by the treatment device is negligible. See Table 6-4, Section 6.1.1.3, for the baseline generation volumes.

6.5   COLLECTION, HOLDING, AND TRANSFER WITHIN 12NM

CHT is the onboard collection, containment, and subsequent transfer of bilgewater to shore facilities or ship waste offload barges (SWOBs). CHT does not involve any treatment of raw bilgewater on board the generating vessel. CHT may require the installation of some shipboard equipment, such as piping or tanks, to provide additional holding capacity. This MPCD option results in no (zero) liquid discharge to surrounding waters within 12 nm.

6.5.1   Characterization Data

Characterization data are comprised of physical parameters, chemical data, field data, and descriptive information. Each of these parameters is discussed below. See Section 6.1.1 for identification of bilgewater sources. However, because this MPCD option results in no (zero) direct liquid discharge to surrounding waters within 12 nm, there are no characterization data to address.

6.5.1.1   Physical Parameters

This MPCD option results in no (zero) direct liquid discharge to surrounding waters within 12 nm; therefore, there are no discharge characteristics to consider.

6.5.1.2   Constituent Data, Classical Data, and Other Descriptors

Chemical Data

Because a waste stream is not directly discharged to surrounding waters within 12 nm for this MPCD option, there are no constituents to consider.

Field Data

Because a waste stream is not directly discharged to surrounding waters within 12 nm for this MPCD option, there are no field data to consider.

Descriptive Information

Because a waste stream is not directly discharged to surrounding waters for this MPCD option, there are no descriptive information data to consider.

6.5.1.3 *Discharge Generation Rates for Mass Loading*

CHT results in no (zero) direct liquid discharge to surrounding waters within 12 nm. Therefore, the annual discharge volume is zero.

6.6 CHARACTERIZATION DATA UNCERTAINTY AND DATA QUALITY FOR DD 963 DISCHARGE

The sources and levels of uncertainty in bilgewater characterization data vary by discharge parameter. This subsection describes the uncertainty associated with physical parameters; constituent data, classical data, and other descriptors; and discharge generation rates.

6.6.1 Physical Parameters Uncertainty and Data Quality for DD 963 Discharge

Schematic Data

The information provided for the physical parameters of DD 963 baseline discharge is based on process knowledge and the vessel specifications of the representative vessel. Certain physical parameter values used in this report, including representative vessel length, discharge port diameter, and distance from centerline to discharge port (transverse), are taken directly from vessel schematics. These parametric values do not vary among vessels in the class. Certain other parameters vary with load conditions. These condition-specific parameters include approximate distance from waterline to discharge port (vertical) and discharge method. The discharge was assumed to occur under full load conditions to facilitate a comparison of baseline and MPCD option performance. This assumption is supported by Armed Forces expert knowledge of ship status, which indicated that when vessels are pierside they typically are loaded for deployment.

Modeling Data

One use of the discharge characterization information is to provide input data for hydrodynamic modeling of a discharge plume within a mixing zone. Modeling is performed to determine plume dilution factors at the edge of a mixing zone. Modeling calculations involve various parameters that include discharge temperature, density (salinity), and vessel attributes related to bilgewater discharge, such as the distance from the discharge port to the waterline. The bilgewater temperature was assumed to be equal to ambient water temperature for modeling purposes. Bilgewater is stored in OWHTs in direct contact with the hull, resulting in temperature equilibration. The bilgewater salinity data was taken from UNDS sampling results. Uncertainty related to sampling is discussed in Section 6.6.2 and applies to the salinity data.

As stated in Section 6.1.1.1, the discharge flow rate used to characterize the discharge is based on the rated capacity of the processor as reported by the manufacturer. The duration of, and time between release events are closely related and are dependent on the volume of the OWHT. The

volume of the OWHT at processing onset determines the duration of the release event. Likewise, the time between release events is related to the capacity of the OWHT and the bilgewater generation rate. A simplifying assumption, that the discharge of bilgewater occurs when the OWHT reaches 90 percent of capacity, was based on knowledge derived from equipment experts.

6.6.2 Constituent Data, Classical Data, and Other Descriptors Uncertainty and Data Quality for DD 963 Discharge

Sampling was conducted aboard the DD 971 according to the SAP (Navy, 2000d). Deviations in sampling practices, analytic testing, laboratory equipment, processing equipment, and specimen handling exist and may affect the results. For more information on the sampling plan, see the DD 971 SAP.

During the sampling episode, deviations from the sampling plan were noted in the SER.

- The flow rates fluctuated during sample collection. To account for the decrease in flow rate, the sampling team manually adjusted the sample valves to isokinetically match the flow rate. This adjustment occurred when the flow rate reached approximately 80 percent of the initial flow rate.

The SER also details issues identified during the sample analysis, including the SCC's review of the analytical data. The reports also contain further details regarding any additional data qualifiers for specific constituents for the samples. A complete description of how qualified data were used in the UNDS program can be found in Section 6.1.1.2.

DD 971 sample data were used to characterize this vessel group. As described in the *Vessel Grouping Representative Vessel Selection for Surface Vessel Bilgewater/Oil Water Separator Discharge (Navy and EPA, 2001a), although subsequent decision making resulted in the selection of DD 963 to represent this vessel group*, process knowledge indicates that there should be no significant differences in bilgewater composition between vessels of the same class.

6.6.3 Discharge Generation Uncertainty and Data Quality for DD 963 Discharge

Bilgewater generation rates for the DD 963 vessel group used in this report to characterize the discharge are estimated based on process knowledge and previously reported values. The UNDS Phase I Surface Vessel Bilgewater/OWS Nature of Discharge Report (NOD) estimates that the average in-port generation rate for a DD Class Vessel is approximately 2,000 gal/day (EPA and DoD, 1999). However, based on actual performance data, the generation rate is 2,500 gal/day in port and 10,000 gal/day underway (Navy, 1997a). Additionally, the five vessel classes that comprise this vessel group vary in vessel size, machinery, and displacement. Vessel engine and auxiliary machinery rooms are the main sources of bilgewater (EPA and DoD, 1999) therefore unlike other discharges, the bilgewater generation rates do not depend on crew size. As a result, having multiple vessel in the group with a wide range of sizes and propulsion plant characteristics results in variation in generation rates and adds uncertainty to this value.